Program & Ancillary Materials

Geospatial Technologies & Geomorphological Mapping

41st Binghamton Geomorphology Symposium

October 15-17, Columbia, SC, USA

Co-Organizers and moderators:
L. Allan James[a], Stephen J. Walsh[b], Michael P. Bishop[c]

[a] Department of Geography, University of South Carolina, Columbia
[b] Department of Geography, University of North Carolina, Chapel Hill
[c] Department of Geography, University of Nebraska, Omaha

Schedule

Friday, October 15

7:45 – 8:45   Registration, Callcott Building main floor lobby

8:15 – 3:30 Field trip to Congaree National Park led by John Kupfer and Kimberly Meitzen, USC. Depart from Callcott Building south basement entrance after registering.

6:30 – 8:30 Registration, Capstone Building Lobby

6:30 – 10:00 Light Reception and Welcoming, Top of Carolina, revolving restaurant with overview of Columbia

Saturday, October 16

7:30 – 10:00 Registration - Callcott Building main floor lobby
7:30 – 8:30 Continental breakfast & Poster Setup, Callcott Building, lower level, Rooms 003 and 004.

8:30 – 10:00   **Session I - INTRODUCTIONS**

8:30 - 8:40 *Welcome to Columbia* - Will Graf, Interim Associate Dean for Research, College of Arts and Sciences, USC

8:40 - 9:10 Convocation: *Taking the Measure of a Landscape: Comparing a Simulated and Natural Landscape in the Virginia Coastal Plain* - Alan D. Howard, Univ. Virginia, Heather E. Tierney, Charlottesville, VA.

9:10 - 9:40 Introduction: *Geospatial Technologies and Digital Geomorphological Mapping: Concepts, Issues, and Research* - Michael P. Bishop, Univ. Nebraska, Omaha; Allan James, Univ. South Carolina; John F. Shroder, Univ. Nebraska, Omaha; Stephen Walsh, Univ. North Carolina, Chapel Hill.

9:40 - 10:10   **Coffee Break & Poster Session I**

10:10-12:30   **Session II - REMOTE SENSING,** *Methods and Technology*

10:10 - 10:40 *Mapping Surface Mineralogy Using Imaging Spectrometry* - Fred A. Kruse , Univ. Nevada, Reno.

10:40 - 11:10 *Airborne and Terrestrial LiDAR Technology for Assessing Topography*, Michael Hodgson and John R. Jensen, Univ. South Carolina.

11:10 - 11:40 *Microwave Remote Sensing* , Scott Hensley, Jet Propulsion Lab.

11:40 - 12:10 *Landform Characterization Using Geophysics - Recent Advances, Applications, and Emerging Tools* - Remke L. Van Dam, Michigan State Univ.

12:10 - 12:30 Discussion

12:30-1:30 **Lunch** in Grand Market next door;   (BGS Steering Committee Meeting)

1:30-3:00   **Session III - REMOTE SENSING,** *Applications*

1:30 - 2:00 *Making Riverscapes Real -* Patrice Carbonneau, Univ. Durham*;* Mark A. Fonstad *,* Texas State Univ., San Marcos*;* W. Andrew Marcus, Univ. Oregon*;* Stephen. J. Dugdale, APEM Ltd., Riverview, Embankment Business Park, Heaton Mersey, UK.

2:00 - 2:30 *High-Resolution Mapping and Modeling of Floodplains -* James Brasington, Univ. Aberystwyth, UK*;* Damià Vericat, U. Aberystwyth and Forest Tech. Centre of Catalunya, Spain.

2:30 - 3:00 *Relationship between Satellite-Derived Snow Cover and Snowmelt-Runoff Timing and Stream Power in the Wind River Range, Wyoming* - Dorothy K. Hall, NASA; James L. Foster; Nicolo E. DiGirolamo; George A. Riggs

3:00 - 3:30 **Coffee Break & Poster Session II**

3:30 - 5:00 **Session IV - GEOGRAPHIC INFORMATION SCIENCE**

3:30 - 4:00 *Geomorphometry and landform mapping: what is a landform?* - Ian S. Evans, Durham Univ., UK.

4:00 - 4:30 *Digital Terrain Modeling* - John Wilson, Univ.Southern California.

4:30 - 5:00 *Scientific Visualization of Landscape and Landforms* - Helena Mitasova, North Carolina State Univ.*;* Russell S. Harmon, U.S. Army Research Lab, Durham, NC; Katherine Weaver, NC State; Nathan Lyons, NC State; Margery F. Overton, NC State.

5:00 - 5:30 Discussion

5:30 - 6:15 Cordial with Refreshments

7:00-9:00 pm **Banquet**: *Synchronization and Scale in Geomorphic Systems* - Jonathan D. Phillips, Univ. Kentucky.

Sunday, October 17

8:00-9:00 **Continental Breakfast & Posters**

Highlight Student Poster Winners

9:00-12:15 **Session V - GEOGRAPHIC INFORMATION SCIENCE**

9:00 - 9:30 *Spatial Analysis and Mapping in Coastal Geomorphology* - Thomas R. Allen, East Carolina Univ., George Oertel, Old Dominion Univ., and Paul Gares, East Carolina Univ.

9:30 - 10:00 *Soil Mapping and Modeling* - Jon Pelletier, Univ. Arizona.

10:00 - 10:30 *GIS-based Hydrological Modeling and Mapping* - Lawrence Band and T. Hwang, Univ. North Carolina, Chapel Hill, T.C. Hales, Univ. Cardiff, James Vose and Chelcy Ford, U.S. Forest Service, Southern Research Station..

10:30 - 11:00 *The influence of mechanical properties on the link between tectonic and topographic evolution* - Peter O. Koons, Univ. Maine, Phaedra Upton, Dunedin Research Centre, New Zealand; Adam D. Barker, Univ. Washington

11:00 - 11:30 *Geomorphic Change Detection Using Historic Maps and DEMs: The Temporal Dimension of Geospatial Analysis* - L. Allan James, Michael Hodgson, Subhajit Ghoshal, and Mary Megison Latiolais, Univ. South Carolina.

11:30-12:15 - Discussion

12:15 **Adjourn**

Vans to the Airport – please sign up in advance

Paper Abstracts

Spatial Analysis and Mapping of Coastal Morphodynamics, Cape Henry, Virginia, U.S.A.

Thomas R. Allen[1], George F. Oertel[2]; Paul A Gares[1]

[1]East Carolina University
[2] Old Dominion University.

Abstract. The advent and proliferation of digital terrain technologies have spawned concomitant advances in coastal geomorphology. Airborne topographic Light Detection and Ranging (LiDAR) has stimulated a renaissance in coastal mapping, and field-based mapping techniques have benefitted from improvements in real-time kinematic (RTK) Global Positioning System (GPS). Varied methodologies for mapping suggest a need to match geospatial products to geomorphic forms and processes, a task that should consider product and process ontologies from each perspective. Towards such synthesis, coastal morphodynamics on a cuspate foreland are reconstructed using spatial analysis. Sequential beach ridge and swale topography are mapped using photogrammetric spot heights and airborne LIDAR data and integrated with digital bathymetry and large-scale vector shoreline data. Isobaths from bathymetric charts were digitized to determine slope and toe depth of the modern shoreface and a reconstructed three-dimensional antecedent shoreface. Triangulated irregular networks were created for the subaerial cape and subaqueous shoreface models of the cape beach ridges and sets for volumetric analyses. Results provides estimates of relative age and progradation rate and corroborate other paleogeologic sea-level rise data from the region. Swale height elevations and other measurements quantifiable in these data provide several parameters suitable for studying coastal geomorphic evolution. Mapped paleoshorelines and volumes suggest the Virginia Beach coastal compartment is related to embryonic spit development from a late Holocene shoreline located some 5 km east of the current beach.

Keywords: coastal geomorphology; spatial analysis; morphodynamics; sea-level rise; cuspate foreland; beach ridges

Ecosystem Processes at the Watershed Scale: Coupled Ecohydrological and Geomorphological Modeling and Mapping

Lawrence E. Band[1], T. Hwang[1], T.C. Hales[2], James Vose[3] and Chelcy Ford[3]

[1]University of North Carolina
[2]University Cardiff
[3]U.S. Forest Service, Southern Research Station

Abstract. Mountain watersheds are sources of a set of valuable ecosystem services as well as potential hazards. The former include high quality freshwater, carbon sequestration, nutrient retention, habitat, biodiversity, and recreation opportunities, while the latter include flash flooding, landslides and forest fire. Each of these ecosystem services and hazards represent different elements of the integrated and co-evolved ecological, hydrological and geomorphic subsystems of the watershed and should be approached analytically as linked land system. Traditional land system inventory by federal resource management agencies have followed a hierarchical mapping paradigm based on a nested geomorphology of land forms, but standard geospatial technologies have often had the unintentional effect of decoupling this approach by emphasizing a "layer-based" approach in which each theme can be independently produced. Emerging ecosystem services packages typically inherit this independent theme treatment of ecosystem services and production functions. We provide alternative approaches to mapping and modeling ecosystem, hydrologic and geomorphic processes and forms within watersheds based on a tightly coupled analytical framework. We illustrate this approach by integrating an ecohydrological modelling system with linked landslide dynamics that includes explicit feedbacks between ecosystem water, carbon and nutrient cycling, and the development of landslide potential in steep forested catchments.

Geospatial Technologies and Digital Geomorphological Mapping: Concepts, Issues and Research

Michael P. Bishop[1], L. Allan James[2], John F. Shroder, Jr. [1], University of Nebraska-Omaha, Stephen J. Walsh[3]

[1]University of Nebraska-Omaha,
[2]University South Carolina
[3]University North Carolina, Chapel Hill.

Abstract. Geomorphological mapping plays an essential role in understanding Earth surface processes, geochronology, natural resources, natural hazards and landscape evolution. It involves the partitioning of the terrain into conceptual spatial entities based upon criteria that includes morphology (form), genetics (process), composition and structure, chronology, environmental system associations (land cover, soils, ecology), as well as spatial topological relationships of surface features (landforms). Historically, the power of human visualization was primarily relied upon, introducing subjectivity and biases with respect to selection of criteria for terrain segmentation and placement of boundaries. New spatio-temporal data and geocomputational algorithms and approaches now permit Earth scientists to go far beyond traditional mapping, permitting quantitative characterization of landscape morphology and the integration of numerous landscape thematic information. Numerous conceptual/theoretical and information technology issues are at the heart of digital geomorphological mapping (DGM), and scientific progress has not kept pace with new and rapidly evolving geospatial technologies. Consequently, we have new capabilities, but numerous issues have not been adequately addressed. Therefore, this paper discusses conceptual foundations and illustrates how geomorphometry and mapping approaches can be used to produce geomorphological information related to the land surface and landforms, process rates, process-form relationships, and geomorphic systems.

Keywords: Digital geomorphological mapping; GIScience; Geomorphometry; Landforms; Remote sensing; Topography

Monitoring and Modelling Floodplain Dynamics: Shining New Light on Riverscapes.

James Brasington[1] and Damià Vericat[1,2]

[1]Aberystwyth University, Institute of Geography and Earth Sciences, UK. jtb@aber.ac.uk
[2]Forest Technology Centre of Catalunya, Spain.

Abstract. In the last decade a technological revolution has transformed the acquisition of geospatial data both above and below the Earth's surface. These developments have profound implications for fluvial geomorphology, creating a step-change in the dimensionality, resolution and precision of measurement. The pace of change has been remarkable. For example, typical datasets of channel morphology have grown from a few tens of cross-sections, containing a few hundred survey observations, to airborne lidar surveys incorporating millions of points. With wide-area terrestrial laser scans comprising tens of billions observations now set to emerge, our data perspectives have expanded by seven orders of magnitude. Coincident with these advances, methods for non-invasive, spatially-distributed measurement of fluvial processes and fluxes have also emerged, in particular, acoustic Doppler velocity profiling. When combined, these 'next-generation' observational technologies create a hitherto unparalleled opportunity to couple the forces, morphological responses and feedbacks that drive the evolution of alluvial rivers at time and space scales relevant to river management. Such rapid modernization nonetheless also brings fresh challenges and requires the development of new data management and processing algorithms, updated spatial metrics and innovative simulation strategies to optimize the dense spatial information. This paper offers some reflections on these opportunities and challenges and illustrates how this recent technology dividend can be used to help bridge the gap between form and process in fluvial geomorphology.

Making Riverscapes Real

Patrice Carbonneau[1], **Mark A. Fonstad**[2*], W. Andrew. Marcus[3], Stephen J.Dugdale[4]

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Abstract. The structure and function of rivers have long been characterized either by: (1) qualitative models such as the River Continuum Concept or Serial Discontinuity Concept which paint broad descriptive portraits of how river habitats and communities vary, or (2) quantitative models, such as downstream hydraulic geometry, which rely on a limited number of measurements spread widely throughout a river basin. In contrast, authors such as Fausch *et al.* (2002) and Wiens (2002) proposed applying existing quantitative, spatially comprehensive ecology and landscape ecology methods to rivers. This new framework for river sciences which preserves variability and spatial relationships is called a riverine landscape or a „riverscape". Application of this riverscape concept requires information on the spatial distribution of organism-scale habitats throughout entire river systems.

This article examines the ways in which recent technical and methodological developments can allow us to quantitatively implement and realize the riverscape concept. Using 3-cm true color aerial photos and 5-m resolution elevation data from the River Tromie, Scotland, we apply the newly developed Fluvial Information System which integrates a suite of cutting edge, high resolution, remote sensing methods in a spatially explicit framework. This new integrated approach allows for the extraction of primary fluvial variables such as width, depth, particle size, and elevation. From these first-order variables, we derive second-order geomorphic and hydraulic variables including velocity, stream power, Froude number, shear stress. Channel slope can be approximated from available topographic data. Based on these first and second-order variables, we produce riverscape metrics that begin to explore how geomorphic structures may influence river habitats, including connectivity, patchiness of habitat, and habitat distributions. The results show a complex interplay of geomorphic variable and habitat patchiness that is not predicted by existing fluvial theory. Riverscapes 57 thus challenge our existing understanding of how rivers structure themselves and will force development of new paradigms.
Key words: Remote sensing, rivers, landscape ecology, riverine habitat, geomorphology

Geomorphometry and Landform Mapping: What is a Landform?

Ian Evans, University of Durham

Abstract. Starting from a concept of the land surface, its definition and subdivision from Digital Elevation Models (DEMs) is considered. High-resolution DEMs from active remote sensing form a new basis for geomorphological work, which is moving on from consideration of whether data are accurate enough to how the surface of interest can be defined from an overabundance of data. Discussion of the operational definition and delimitation of specific landforms of varying degrees of difficulty, from craters to mountains, is followed by the applicability of 'fuzzy' boundaries. Scaling, usually allometric, is shown to be compatible with the scale-specificity of many landforms: this is exemplified by glacial cirques and drumlins. Classification of a whole land surface is more difficult than extraction of specific landforms from it. Well-dissected fluvial landscapes pose great challenges for areal analyses. These are tackled by the delimitation of homogeneous elementary forms and / or land elements in which slope position is considered. Their boundaries are mainly breaks in gradient or aspect, but may also be in some type of curvature: breaks in altitude are rare. Elementary forms or land elements are grouped together into functional regions (landforms) such as 'hill sheds'. It may often be useful to recognize fuzziness of membership, or core and periphery of a surface object.

Plains and etched or scoured surfaces defy most of these approaches, and general geomorphometry remains the most widely applicable technique. It has been applied mainly within arbitrary areas, and to some extent to drainage basins, but more experimentation with mountain ranges and other landforms or landform regions is needed. Geomorphological mapping is becoming more specialized, and its legends are

being simplified. Its incorporation into Geographical Information Systems (GIS) has required greater precision with definitions, and the separation of thematic layers, so that it is converging with specific geomorphometry and becoming more flexible and more applicable, with a broader range of visualization techniques.

Keywords: scaling; allometry; operational definitions; landform delimitation; DEMs

Relationship between Satellite-Derived Snow Cover and Snowmelt-Runoff Timing and Stream Power in the Wind River Range, Wyoming

Dorothy K. Hall[1], James L. Foster[1], Nicolo E. DiGirolamo[2] and George A. Riggs[2]
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Abstract. Earlier onset of springtime weather including earlier snowmelt has been documented in the western United States over at least the last 50 years. Because the majority (>70%) of the water supply in the western U.S. comes from snowmelt, analysis of the declining spring snowpack (and shrinking glaciers) has important implications for streamflow management. The amount of water in a snowpack influences stream discharge which can also influence erosion and sediment transport by changing stream power, or the rate at which a stream can do work such as move sediment and erode the stream bed. The focus of this work is the Wind River Range (WRR) in west-central Wyoming. Ten years of Moderate-Resolution Imaging Spectroradiometer (MODIS) snow-cover, cloud-gap-filled (CGF) map products and 30 years of discharge and meteorological station data are studied. Streamflow data from six streams in the WRR drainage basins show lower annual discharge and earlier snowmelt in the decade of the 2000s than in the previous three decades, though no trend of either lower streamflow or earlier snowmelt was observed using MODIS snow-cover maps *within* the decade of the 2000s. Results show a statistically-significant trend at the 95% confidence level (or higher) of increasing weekly maximum air temperature (for three out of the five meteorological stations studied) in the decade of the 1970s, and also for the 40-year study period. MODIS-derived snow cover (percent of basin covered) measured on 30 April explains over 89% of the variance in discharge for maximum monthly streamflow in the decade of the 2000s using Spearman rank correlation analysis. We also investigated stream power for Bull Lake Creek Above Bull Lake from 1970 to 2009; a statistically-significant trend toward reduced stream power was found (significant at the 90% confidence level). Observed changes in streamflow and stream power may be related to increasing weekly maximum air temperature measured during the 40-year study period. The strong relationship between percent of basin covered and streamflow indicates that MODIS data is useful for predicting streamflow, leading to improved reservoir management.

Key words: Wind River Range, MODIS, seasonal snow cover, streamflow runoff

Geomorphology and Microwave Remote Sensing

Scott Hensley, Jet Propulsion Laboratory, California Institute of Technology

Abstract. The scientific study of landforms and the processes that shape them have benefited tremendously from the rapid progress in remote sensing and computer technologies. Microwave sensors have the ability to inform studies at length scales ranging from planetary scales down to surface roughness at the centimeter scale. This tremendous range of applicability of microwave sensors is a result of the variety of sensor types and the large frequency range over which these sensors operate. Operating from both airborne and spaceborne platforms the suite of microwave sensors has had a profound influence in our understanding of landforms and the processes that shaped and continue to shape them. In addition to their standalone intrinsic value to geomorphological studies these sensors can be combined synergistically with other sensor data, e.g., lidar, optical or hyperspectral data. This talk will focus on the basic theory of how these sensors operate and some of their applications to geomorphology.

Airborne and Terrestrial LiDAR Technology for Assessing Topography

Michael E. Hodgson and John R. Jensen, Department of Geography, University of South Carolina

Abstract. Airborne LiDAR sensors and their geometric control are evolving rapidly. Post-processing methods and to some extent, collection approaches, have also evolved during the last twenty-five years. A comparison of research results from one 'lidar-based' study to another is generally inappropriate unless the sensor, collection parameters, and processing methods are also compared. Profiling LiDAR systems were developed and applied to a variety of applications in the 1980s while scanning LiDAR systems became widespread in the 1990s. In the first decade of the 21st Century, airborne LiDAR systems have become commonplace for collecting terrain data for project areas, complete counties, and even entire states. In the paper we present the key characteristics of LiDAR sensors/platforms and processing methods of interest to geomorphologists, noting their evolutionary history and current state. Using examples of LiDAR-based studies over the last twenty five years, we describe our results of mapping topography and selected features using a variety of sensors and methods. Finally, in difference to common uses of LiDAR data, we provide comments on new approaches using LiDAR that may be developed for geomorphic studies.

Keywords: topography, terrain mapping, GIScience, LiDAR.

Taking the Measure of a Landscape: Comparing Simulated and Natural Landscapes in the Virginia Coastal Plain, USA

Alan D. Howard, University of Virginia, Heather E Tierney, Charlottesville, VA.

Abstract. A landform evolution model is used to investigate the historical evolution of a fluvial landscape along the Potomac River in Virginia, USA. The landscape has developed on three terraces whose age spans 3.5 Ma. The simulation model specifies the temporal evolution of base level control by the river as having a high-frequency component of the response of the Potomac River to sea level fluctuations superimposed on a long-term epeirogenic uplift. The terraces are assumed to form instantaneously during sea level highstands. The region is underlain by relatively soft coastal plain sediments with high intrinsic erodibility. The survival of portions of these terrace surfaces up to 3.5 Ma is attributable to a protective cover of vegetation. The vegetation influence is parameterized as a critical shear stress to fluvial erosion whose magnitude decreases with increasing contributing area. The simulation model replicates the general pattern of dissection of the natural landscape, with decreasing degrees of dissection of the younger terrace surfaces. Channel incision and relief increase in headwater areas is most pronounced during the relatively brief periods of river lowstands. Imposition of the wave-cut terraces onto the simulated landscape triggers a strong incisional response. By both qualitative and quantitative measures the model replicates in a general way the landform evolution and present morphology of the target region.

Keywords: Simulation model; Landform evolution; Morphometry; Vegetation; Base level; Virginia

Geomorphic Change Detection Using Historic Maps and DEM Differencing: The Temporal Dimension of Geospatial Analysis

L. Allan James, Michael E. Hodgson, Subhajit Ghoshal, Mary Megison Latiolais

Abstract. The ability to develop spatially distributed models of topographic change is presenting new capabilities in geomorphic research. High resolution maps of elevation change indicate locations, processes, and rates of geomorphic change, and provide a means of calibrating temporal simulation models. Methods of geomorphic change detection (GCD), based on gridded models, may be applied to a wide range of time periods by utilizing cartometric, remote sensing, or ground-based topographic survey data to measure volumetric change. Advantages and limitations of historical DEM reconstruction methods are reviewed with a focus on coupling them with subsequent DEMs to construct DEMs of difference (DoD); i.e., subtracting one elevation model from another, to map erosion, deposition, and volumetric change. The period of DoD analysis can be extended to several decades if accurate historical DEMs can be generated by extracting topographic data from historical data and selecting areas where geomorphic change has been substantial. The challenge is to recognize and minimize uncertainties in data that are particularly elusive with early topographic data. This paper reviews potential sources of error in digitized

topographic maps and DEMs. It is primarily a review of methods, but three brief examples are presented at the end to demonstrate GCD using DoDs constructed from data extending over periods ranging from 70 to 90 years.

Keywords: cartometry, geomorphometry, change detection, historic maps, DEMs, error analysis

The Influence of Mechanical Properties on the Link Between Tectonic and Topographic Evolution

Peter O. Koons[1], Phaedra Upton[2]; Adam D. Barker[3]
[1]University of Maine   [2]Dunedin Research Centre, Dunedin, New Zealand
[3] University of Washington

Abstract.   In actively deforming orogens, the material strength at the earth surface is controlled in part by strain localization determined by the local stress fields which in turn are driven by contributions from local topography and far field plate velocities. Material weakening associated with strain localization imparts partially predictable, and entirely inescapable heterogeneity to the material fabric of an orogen. The characteristic damage structure of individual fault zones that undergo strain weakening, as imaged in dam site excavations, deep drill holes and geological observations, results in geomorphically relevant strength variations normal to the fault of many orders of magnitude. The sensitivity of both hillslope and fluvial erosion to the strength parameters coupled with the large and oriented strain-related strength variations, causes the topographic evolution to be dominated by tectonically driven rheological behavior at multiple wavelengths. Using three-dimensional, lithospheric scale modeling of two oblique orogens, Southern Alps, New Zealand and the Eastern Himalayan Syntaxis, we examine the generation of a model surface strength field that occurs as a consequence of a simple strain softening upper crustal rheological model. Mapping of topographic anisotropy of the Southern Alps and the Eastern Himalaya Syntaxis indicates azimuthal control on correlation distances that are spatially related to the different strain regimes of the two orogens. By defining landscape evolution in terms of mechanical failure in the conventional motion: stress mechanical framework, the behavior of the earth surface can be brought into the same theoretical framework as the behavior of the sub-surface and many of the observational:theoretical inconsistencies arising from application of dominantly potential field theory can be obviated. Heterogeneity and anisotropy of material strength is a fundamental aspect of active orogens and description of the strength field in terms of mechanical evolution can significantly extend present earth surface models.

Keywords: Cohesion; Anisotropy; Landscape evolution

Mapping Surface Mineralogy Using Imaging Spectrometry

Fred A. Kruse, University of Nevada, Reno

Abstract.   Imaging spectrometry, simultaneous measurement of spectra and images in up to hundreds of spectral channels or bands, is a proven technology for identifying and mapping minerals based on their reflectance or emissivity signatures. Also known as hyperspectral imaging or "HSI", extraction of key spectral signatures from these data allows identification of iron minerals such as hematite, goethite, and jarosite in the visible/near infrared (VNIR); clays, carbonates, micas, sulfates, and other minerals in the short wave infrared (SWIR); and silicates and carbonates in the long wave infrared (LWIR). The unique capability of imaging spectrometry to produce detailed maps of the spatial distribution of specific minerals, mineral assemblages, and mineral variability on the surface of Earth makes it an ideal tool for enhanced geomorphic mapping. Case histories illustrate the use of HSI for characterizing and mapping active and relict geothermal/hydrothermal systems and determining relations between mineralogy and derived landforms. Imaging spectrometry, used in conjunction with complimentary datasets such as InSAR (Interferometric Synthetic Aperture Radar), Light Detection and Ranging (LiDAR), or stereo (photogrammetric-derived) digital elevation models (DEMs), provides a unique means of visualizing the spatial distribution and association of mineralogy with topography, thus contributing to the understanding of the relations between geology and landscape and to improved interpretation of surface geologic processes.

Keywords: Spectral Mineral Mapping, Remote Sensing Geomorphology, Imaging Spectrometry, Hyperspectral Imagery (HSI), 3-D Geologic Visualization

Scientific Visualization of Landscapes and Landforms

Helena Mitasova[1], Russell S. Harmon, Katherine Weaver[1]; Nathan Lyons[1]; Margery F. Overton[1]
[1]North Carolina State University,
[2]U.S. Army Research Laboratory, Durham, NC

Abstract. Scientific visualization of geospatial data provides highly effective tools for analysis and communication of information about the land surface and its features, properties, and temporal evolution. While single-surface visualization of landscapes is now routinely used in presentation of earth surface data, interactive 3D visualization based upon multiple elevation surfaces and cutting planes is gaining recognition as a powerful tool for analyzing landscape structure based on multiple return lidar data. This approach also provides valuable insights into land surface changes captured by multi-temporal elevation models. Thus, animations using 2D images and 3D views are becoming essential for communicating results of landscape monitoring and computer simulations of earth processes. Multiple surfaces and 3D animations are also used to introduce novel concepts for visual analysis of terrain models derived from time-series of lidar data using multi-year core and envelope surfaces. Analysis of terrain evolution using voxel models and visualization of contour evolution using isosurfaces has potential for unique insights into geometric properties of rapidly-evolving coastal landscapes. In addition to visualization on desktop computers, the coupling of GIS with new types of graphics hardware systems provides opportunities for cutting-edge applications of visualization for geomorphological research. These systems include tangible environments that facilitate intuitive 3D perception, interaction and collaboration. Application of a Tangible Geospatial Modeling System for exploration of surface water flow adaptation to changing landforms and structures illustrates the potential of this emerging technology to improve our current understanding of interactions between the changes in terrain shape and landscape fluxes.

Keywords: Digital Elevation Model; Hillshade; Elevation time series; Lidar; Animation; Tangible geospatial modeling; GRASS GIS; Smoky Mountains; Jockey's Ridge sand dunes

Numerical modeling/mapping of soil thicknesses and erosion rates in upland landscapes

Jon Pelletier, University of Arizona.

Abstract. The thicknesses of soil in upland (soil over bedrock) landscapes are controlled by the difference between soil production and erosion. In this talk, I review quantitative models for soil production and soil erosion and apply those models to modeling/mapping soil thickness and erosion rates at high resolution using airborne-LiDAR DEMs. Modeling soil thickness is useful because many numerical models for climate and hydrology require input data for spatially-distributed soil thickness, and, in the absence of better constraints, overly simplistic assumptions (e.g. uniform 2-m-thick soils) are often made. I show how, using a small number of local calibration points for soil thickness measured in soil pits, it is possible to model/map soil thickness across landscapes. I illustrate/test this technique in three study areas: the Santa Catalina Mountains (AZ), the Granite Mountains (CA), and the Banco Bonito volcanic flow (NM). I also review our knowledge of the quantitative controls on rates of soil production and present a predictive equation for soil production/bedrock weathering based on climate, rock type, and soil thickness. Armed with this equation, I show how soil thickness maps can be used to model/map erosion rates over geologic time scales. Along the way, I emphasize the strong coupling between climate, topography, and soil thickness. I will also emphasize the open questions and limitations of existing models in this area of study in hopes of stimulating new ideas and collaborations.

Synchronization and Scale in Geomorphic Systems

Jonathan Phillips, University of Kentucky

Abstract. Geomorphic systems consist of coupled subsystems with traits of small-world networks (SWN), characterized by tightly connected clusters of components, with fewer connections between the clusters. Geomorphic systems with subsystems based on scale hierarchies often exhibit a connected caveman small-world network (CCSWN) structure. SWNs are efficient for linking a large number of components with a relatively small number of links; but effects of CCSWN structure on synchronization and scale linkage have not been examined. Synchronization is analyzed via graph theory, which is applied

to three geomorphic systems: (1) relationships among three levels of formprocess interaction in stream channels; (2) the hierarchical relationships of weathering systems at scales from weathering profiles to landscapes; and (3) interactions in fluviokarst systems at the scale of flow processes and of landscape evolution. Relationships among system components are represented as simple unweighted graphs. The largest eigenvalue of the adjacency matrix (spectral radius) reflects the critical coupling strength required to synchronize the system. The second-smallest eigenvalue of the Laplacian of the adjacency matrix (algebraic connectivity) is a measure of the synchronizability. In all examples both are much less than the maximum for networks of the same number of nodes. The sparseness of the networks is the major contributor to the low synchronization, but the specific pattern of connections ("wiring") is also significant. Where CCSWN structures arise naturally, they help explain how geomorphic effects are transmitted between disparate scales in the absence of obvious scale linkage. Where CCSWNs are an option for representation of geomorphic systems in models and data structures, they will not improve scale linkage, despite the efficiency of SWNs in other respects.

Keywords: Scale linkage; Synchronization, Geomorphic systems, Connected caveman small-world network, Stream channels, Weathering systems, Fluviokarst

Landform Characterization Using Geophysics: Recent Advances, Applications, and Emerging Tools

Remke L. Van Dam, Michigan State University.

Abstract. This paper presents an overview of the strengths and limitations of existing and emerging geophysical tools for landform studies. The objectives of this paper are to discuss recent technical developments and to provide a review of relevant recent literature, with a focus on propagating field methods with terrestrial applications. For various methods in this category, including groundpenetrating radar (GPR), electrical resistivity (ER), seismics, and electromagnetic (EM) induction, the technical backgrounds are introduced, followed by section on novel developments relevant to landform characterization. For several decades, GPR has been popular for characterization of the shallow subsurface and in particular sedimentary systems. Novel developments in GPR include the use of multi-offset systems to improve signal-to-noise ratios and data collection efficiency, amongst others, and the increased use of 3D data. Multi-electrode ER systems have become popular in recent years as they allow for relatively fast and detailed mapping. Novel developments include time-lapse monitoring of dynamic processes as well as the use of capacitively-coupled systems for fast, non-invasive surveys. EM induction methods are especially popular for fast mapping of spatial variation, but can also be used to obtain information on the vertical variation in subsurface electrical conductivity. In recent years there have been several examples of the use of plane-wave EM for characterization of landforms. Seismic methods for landform characterization include seismic reflection and refraction techniques and the use of surface waves. A recent development is the use of passive sensing approaches. The use of multiple geophysical methods, which can benefit from the sensitivity to different subsurface parameters, is becoming more common. Strategies for coupled and joint inversion of complementary datasets will, once more widely available, benefit the geophysical study of landforms.

Three cases studies are presented on the use of electrical and GPR methods for characterization of landforms in the range of meters to 100's of meters in dimension. In a study of polygonal patterned ground in the Saginaw Lowlands, Michigan, USA, electrical resistivity tomography was used to characterize subsurface textural and water content differences associated with polygon-swale topography. Also, a sand-filled thermokarst feature was identified using electrical resistivity data. The second example is on the use of constant spread traversing (CST) for characterization of large-scale glaciotectonic deformation in the Ludington Ridge, Michigan. Multiple CST surveys parallel to an ~60 m high cliff, where broad (~100 m) synclines and narrow clay-rich anticlines are visible, illustrated that at least one of the narrow structures extended inland. A third case study discusses internal structures of an eolian dune on a coastal spit in New Zealand. 35 and 200 MHz GPR data, which clearly identified a paleosol and internal sedimentary structures of the dune, where used to improve understanding of the dune's development, which may shed light on paleo wind directions.
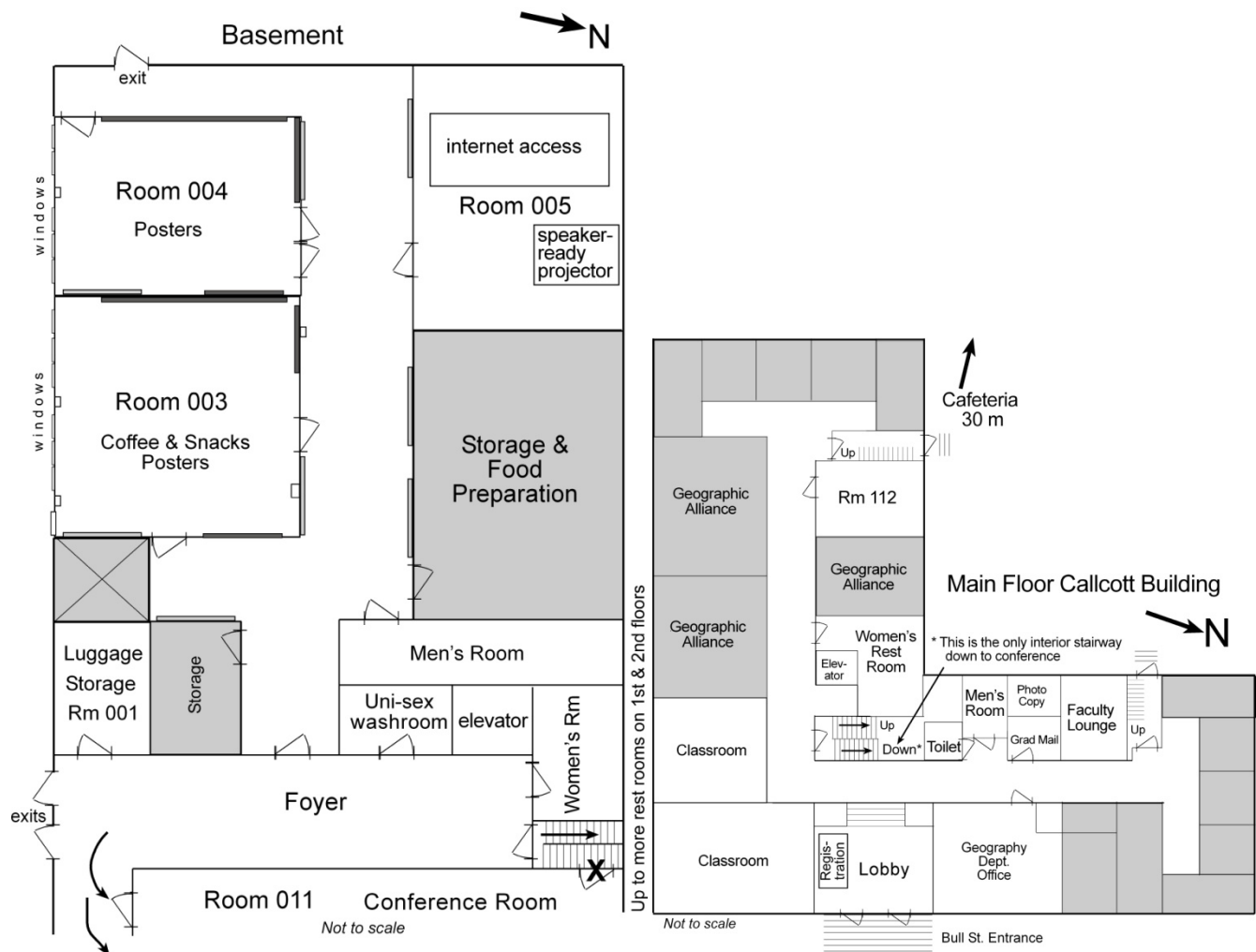
Keywords: Geophysics, landforms, subsurface characterization, electrical resistivity, groundpenetrating radar

Digital Terrain Modeling

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Abstract. This article examines how the methods and data sources used to generate DEMs and calculate land surface parameters have changed over the past 25 years. The primary goal is to describe the state-of-the-art for a typical digital terrain modeling workflow that starts with data capture, continues with data preprocessing and DEM generation, and concludes with the calculation of one or more primary and secondary land surface parameters. The article first describes some of ways in which LiDAR and RADAR remote sensing technologies have transformed the sources and methods for capturing elevation data. It next discusses the need for and various methods that are currently used to preprocess DEMs along with some of the challenges that confront those who tackle these tasks. The bulk of the article describes some of the subtleties involved in calculating the primary land surface parameters (that are derived directly from DEMs without additional inputs) and the two sets of secondary land surface parameters that are commonly used to describe solar radiation and the accompanying interactions between the land surface and the atmosphere on the one hand and water flow and related surface processes on the other. It concludes with a discussion of the various kinds of errors that are embedded in DEMs, how these may be propagated and carried forward in calculating various land surface parameters, and the consequences of this state-of-affairs for the modern terrain analyst.

Keywords: Digital Elevation Models; Land Surface Parameters; Error Propagation

Posters

Name	Title	Affiliation
Ben Allen	The Effects of Mill Dams on Suspended Sediment Yield, Northern Baltimore County, Maryland	Towson University
Jane Atha	Fluvial Wood Presence and Dynamics over a Thirty Year Interval in Forested Watersheds	Texas State, San Marco
William D. Butler	Repeat Photography Documents Short-Term Landscape Changes in Geothermal Features in Yellowstone National Park, Wyoming	Kansas State U.
Christopher L. Coffey and Jeffrey D. Colby	Optimal Drainage Pattern Delineation and Evaluation of the Terrain Data Model	Appalachian State Univ
Christopher Crosby, Viswanath Nandigam, Sriram Krishnan, Chaitan Baru, J Ramon Arrowsmith	The OpenTopography Facility: Providing Online Access to High-Resolution LiDAR Topography Data for Geomorphology Research	UC San Diego and Arizona State U. (Arrowsmith)
James T. Dietrich	Visualizing small-scale geomorphic features using 3D models derived from Microsoft Photosynth	Texas State, San Marco
Margherita Di Leo and Salvatore Manfreda	Correlation of hydrological response and local and global slope	Universita' degli Studi della Basilicata, Potenza, Italy
Elizabeth Ervin and Veronica Moore	Working with LiDAR data in Florence County	Florence County & Northwest Missouri State U
Anthony M. Filippi, Inci Güneralp, and Joonghyeok Heo	Algorithmic and Data Comparisons for River Flow-Boundary Extraction from Remote-Sensor Images	Texas A&M University
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